PEARY CARIBOU AND MUSKOXEN ON BATHURST ISLAND, NORTHWEST TERRITORIES, FROM 1961 TO 1981

Northwest Territories Renewable Resources

103-05890/

PEARY CARIBOU AND MUSKOXEN ON BATHURST ISLAND, NORTHWEST TERRITORIES, FROM 1961 TO 1981

MICHAEL A.D. FERGUSON
DEPARTMENT OF RENEWABLE RESOURCES
GOVERNMENT OF THE NORTHWEST TERRITORIES
POND INLET, NWT

1991

File Report No. 88

Northwest Territories Renewable Resources

ABSTRACT

To determine whether or not Peary caribou (Rangifer tarandus pearyi) and muskoxen (Ovibos moschatus) had recovered since the early 1970s, I conducted an aerial survey of Bathurst Island, Northwest Territories, during the period 10-13 August 1981. I estimated populations of 289 caribou and 208 muskoxen on Bathurst Island. Sampling intensity was 26%, except for 74% over Polar Bear Pass (2% of the island's area). The minimum count of 229 muskoxen indicated that a large proportion of the population was observed. The 1981 caribou and muskox estimates were slightly greater than August 1974 estimates of 231 caribou and 164 muskoxen. The 1981 caribou population was 11% of the 2723 estimated in 1961; while the 1981 muskox estimate was 18% of the 1136 estimated in 1961.

In 1981, the proportion of calves among observed animals was 19% for caribou and 16% for muskoxen. Thus calf production and/or survival in 1981 was significantly greater than in 1974 when no calves were observed, and similar to that in 1961. After excluding solitary animals (7% of all groups), caribou group size averaged 5.6 in August 1981, as expected from past studies. Muskox groups (after excluding solitary animals, 12% of all groups) averaged 10.2 animals, which was about normal for the time of year.

During the period 10-13 August 1981, Bathurst Island caribou were concentrated north of 76°20'N, the northernmost limit of their seasonal migration. Caribou preferred elevations of 151-300 m above sea level (ASL). Muskoxen were concentrated in southern and central Bathurst Island; preferring elevations below 150 m ASL. The clear spatial separation of the two species indicated little or no range overlap during mid-summer.

TABLE OF CONTENTS

ABSTRACT iii

LIST OF FIGURES vii

LIST OF TABLES ix

INTRODUCTION 1

STUDY AREA 4

METHODS 6

RESULTS AND DISCUSSION 9
Peary Caribou 9
Population Size and Trends 9
Calf Production 13
Group Size 17
Distribution 18
Muskoxen 26
Population Size and Trends 26
Calf Production 31
Group Size 32
Distribution 34
Range Overlap and Potential for Competition 37
Management and Study Implications 39

RECOMMENDATIONS 44

ACKNOWLEDGEMENTS 46

PERSONAL COMMUNICATIONS 47

LITERATURE CITED 48

APPENDIX A: Population Estimates for Peary Caribou in the Canadian Arctic 51

APPENDIX B: Numbers of Peary caribou and muskoxen counted within 1.6-km strip-transects in sampling strata on Bathurst Island, Northwest Territories, 10-13 August 1981 53

LIST OF FIGURES

Figure 1. Queen Elizabeth Islands (north of 74°N), Northwest Territories, Canada 2

Figure 2. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, during an aerial survey, 10-13 August 1981 7

Figure 3. Snow cover conditions during the winters of 1973-74 and 1980-81 at Resolute Airport, Cornwallis Island, Northwest Territories 16

LIST OF TABLES

Table 1. Numbers and densities of Peary caribou on Bathurst Island, Northwest Territories, from an aerial survey, 10-13 August 1981 10

Table 2. Changes in estimated numbers of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from 1961 to 1981 11

Table 3. Percentages of calves among Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from an aerial survey, 10-13 August 1981 14

Table 4. Group sizes of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, during an aerial survey, 10-13 August 1981 19

Table 5. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, by sampling strata, 10-13 August 1981 20

Table 6. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, by elevational zones, 10-13 August 1981 23

Table 7. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, by distance from the seacoast, 10-13 August 1981 24

Table 8. Numbers and densities of muskoxen on Bathurst Island, Northwest Territories, from an aerial survey, 10-13 August 1981 27

INTRODUCTION

From the first systematic aerial survey of Bathurst Island, Northwest Territories in summer 1961, Tener (1963) estimated that there were 2723 Peary caribou and 1136 muskoxen. Tener's estimates of muskox numbers were "only provisional guesses", except for southern and northwestern Bathurst Island. Tener's estimate of the caribou population was obtained through normal data analysis; however, his caribou estimate may have been low. "Undoubtedly some animals, particularly caribou, were missed" on southern Bathurst Island because of a confusing pattern of snow patches on bare ground (Tener 1963: 11).

Subsequent surveys indicated population declines of about 90% for caribou and 85% for muskoxen by the summer of 1974 (Fischer and Duncan 1976, Miller et al. 1977a). Concurrently caribou populations declined throughout the western Queen Elizabeth Islands (Figure 1); ultimately because of low productivity and high mortality. These conditions were apparently caused by reduced forage availability due to early snowfalls, deep and prolonged snow cover, and ground-fast ice (Miller et al. 1975).

From 1960 to 1974, Inuit hunters of Resolute harvested caribou primarily from Bathurst Island (Riewe 1976). Inuit are concerned that oil and gas exploration on Bathurst Island may have been responsible for, or contributed to, the caribou

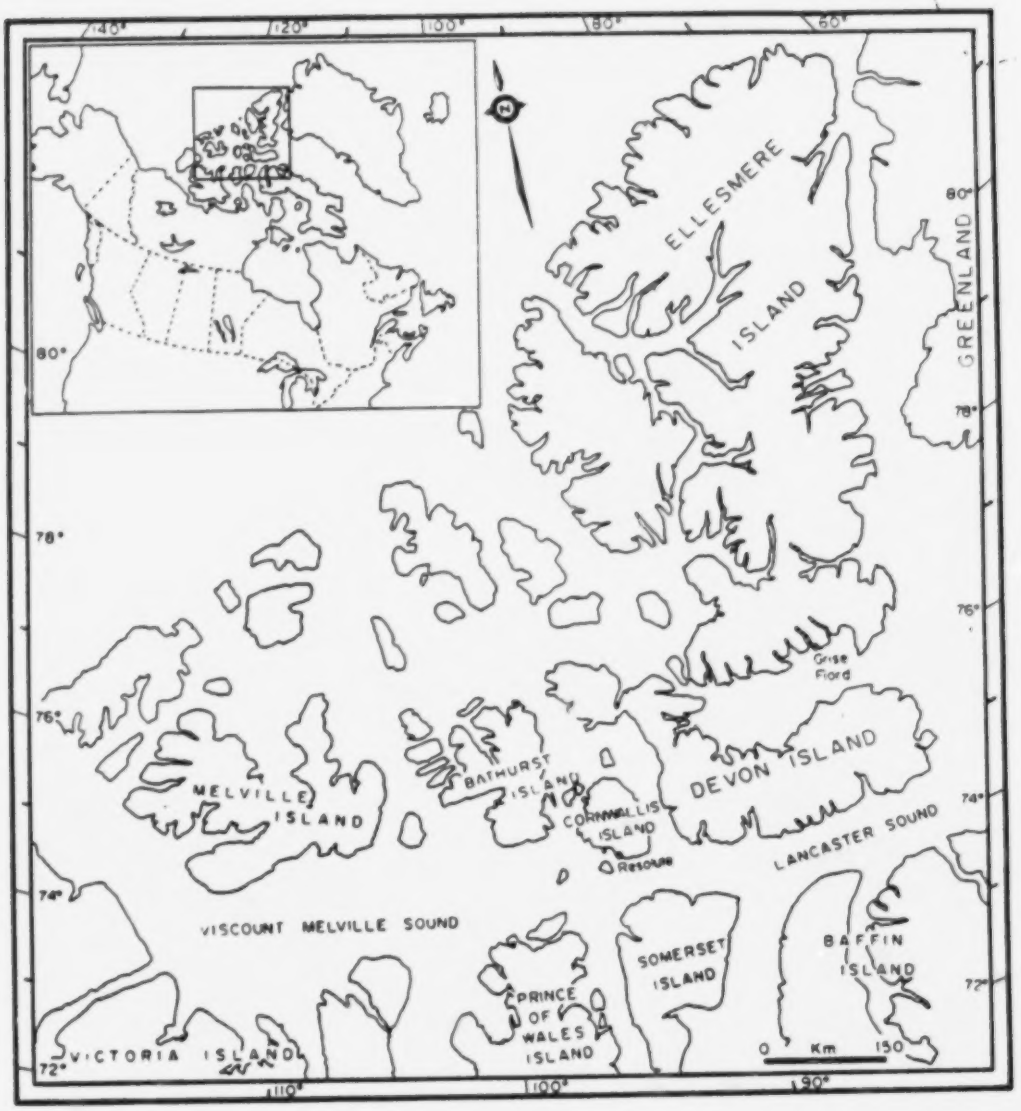

Figure 1. Queen Elizabeth Islands (north of 74°N), Northwest Territories, Canada.

decline in 1973-74. Concerns of Inuit and others about the status of Peary caribou and muskoxen on the Queen Elizabeth Islands (QEI) will escalate if exploration continues, mines are developed, human populations increase, and oil and gas transportation to southern markets is developed.

In 1974 Inuit hunters of Resolute voluntarily suspended harvesting caribou on Bathurst Island to allow the population to recover. Hunters have since harvested caribou mainly on Somerset and Prince of Wales islands across Barrow Strait. Some harvesting occurred on Cornwallis Island until 1982 when the Inuit extended their voluntary ban to Cornwallis and some other islands. In August 1981, the Department of Renewable Resources conducted an aerial survey of Bathurst Island to determine numbers and distributions of Peary caribou and muskoxen; and to evaluate current calf productivity.

STUDY AREA

With numerous, long inlets, 25% of Bathurst Island (16,070 km^2) is within 2.5 km of the coast, and 73% is within 10 km (Figure 1). Generally, topographical changes on Bathurst Island are not extreme, with 63% of the island below 150 m above sea level (ASL), and less than 1% above 300 m ASL. In the northern three-quarters of the island, erosion and east-northeast folds of bedrock have produced uplands with regular and continuous ridges. The gently undulating plateau of the southern quarter is less well-drained with many small ponds in the southwest.

Polar Bear Pass, located between Goodsir and Bracebridge inlets, "...is the most significant area for wildlife of Bathurst Island" (Nettleship and Smith 1975). The Pass is characterized by lowlands with numerous tundra ponds that lie between parallel ridges of folded bedrock. Polar Bear Pass was part of an Ecological Site designated by the International Biological Programme, and is now protected as a National Wildlife Area. The Area has 26 species of nesting birds, and is important to muskoxen during calving, the rut and late winter. Peary caribou and polar bears (Ursus maritimus) migrate through the site seasonally.

Bathurst Island's flora has not been well documented, but is probably typical of the western QEI (Porsild 1955). In the early 1960s, the vegetation was apparently relatively rich over

much of the Island (Tener 1963). However, because of the low proportions of preferred forage in the diets of Bathurst Island caribou and muskoxen, Parker (1978) suggested that their range has deteriorated due to past over-utilization.

Winters on Bathurst Island are slightly colder than Resolute, 150 km southeast of Polar Bear Pass. Severe winters, characterized by early winter ice storms and snowfall, and snow cover remaining into July, occur irregularly in the western QEI. From December to March, temperatures average less than -18°C. The mean daily temperature is usually above 0°C from mid-June to mid-September. The snow-free period normally extends from early July to late August; while the greatest snowfall occurs in September and October (Miller et al. 1977a). During the period 10-13 August 1981, snow was accumulating on Bathurst Island, north of Polar Bear Pass at elevations above 100 m ASL.

METHODS

Peary caribou and muskoxen on Bathurst Island were censused from 10 to 13 August 1981 using a standard aerial strip-transect method. Tape on wing struts delineated a 0.8-km strip on each side of the Cessna 337 aircraft, which was flown 122 m above ground level (AGL), and at 190-210 km/h. The 0.8-km strips fell beyond the blind zone directly below the aircraft. In each of sampling strata 1, 2 and 3 (Figure 2) parallel, northerly transects were spaced 6.4 km apart to provide a sampling intensity of approximately 25%. In stratum 4, east-northeasterly transects were flown 1.6 km apart to provide about 75% coverage, after accounting for the blind zone. Animal group locations were indicated on 1:250,000 topographical maps by the pilot, and two rear observers counted and recorded animals as being calves or older animals, and as being inside or outside the census strip. If all calves and/or older animals could not be counted from the transects, groups were circled to obtain accurate counts. All flights were based out of Resolute, resulting in extensive ferrying over stratum 3.

Using animal numbers counted within strip-transects, densities, estimated numbers and standard errors were calculated with ratio-estimator formulae (Cochran 1963, Miller et al. 1977a). Distributions of land area by strata, elevation zones and distance-from-seacoast zones were determined from 1:250,000

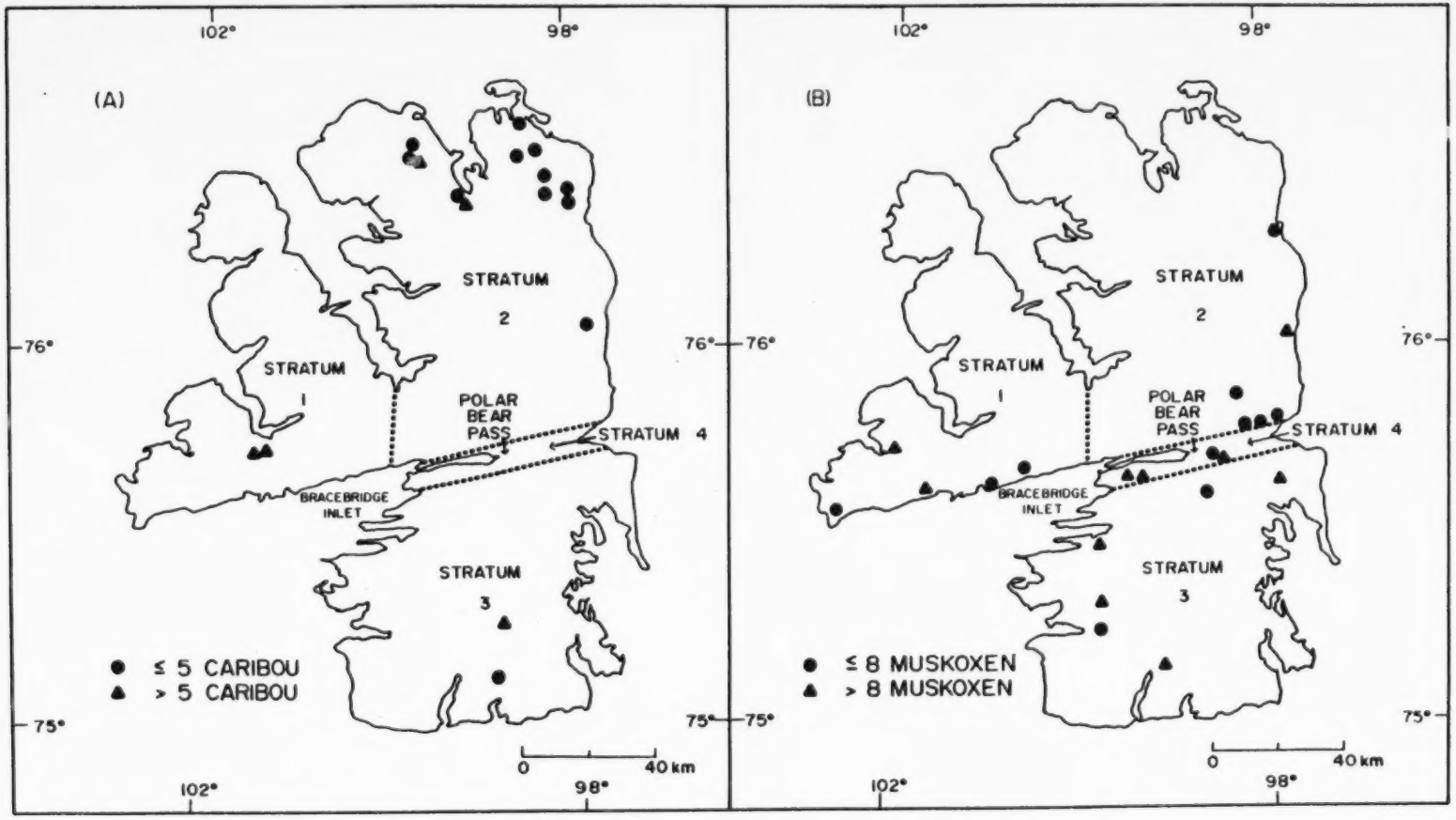

Figure 2. Distribution of Peary caribou (A) and muskoxen (B) on Bathurst Island, Northwest Territories, during an aerial survey, 10-13 August 1981.

topographical maps. Animal preferences of certain strata or zones were evaluated by Chi^2 tests, based on the proportion of land area surveyed in each stratum or zone. Data for these analyses included animals observed within and outside strip-transects during the survey. Chi^2 tests were also used to compare the proportion of calves in each stratum, based on the overall proportion of calves in all observed groups.

RESULTS AND DISCUSSION

Peary Caribou

Population Size and Trends

The caribou population on Bathurst Island was estimated at 289 for the period 10-13 August 1981 (Table 1). A confidence interval for this estimate could not be determined because of the untransformable, non-normal distribution of the data; caused by the clumped distribution of the small number of observed caribou (74).

The Bathurst Island caribou population declined by 74% between 1961 and 1973 (Table 2). A crash of a further 68% followed between the summers of 1973 and 1974. The 1981 estimate suggested a 25% increase since August 1974. These estimates could not be compared statistically because of the non-normal data.

Fischer and Duncan (1976) estimated that 228 caribou were on Bathurst Island and smaller islands to the north and west during 18-25 August 1974. About 22% of the caribou observed on and off transect during Fischer and Duncan's survey were on the smaller islands. Miller et al. (1977a) estimated that there were 231 on Bathurst Island alone during 25-26 August 1974. Thus it appears that Fischer and Duncan's estimate for Bathurst Island alone would have been about 20-25% less than Miller et

Table 1. Numbers and densities of Peary caribou on Bathurst Island, Northwest Territories, from an aerial survey, 10-13 August 1981.

Sampling stratum[1] (Sampling intensity)	Number of caribou counted During survey: Within 1.6-km transects	Number of caribou counted During survey: Outside transects	Number of caribou counted During ferrying[2]	Number of caribou per 100 sq km[3]: Mean	Number of caribou per 100 sq km[3]: Standard error	Estimated number of caribou[3]: Total	Estimated number of caribou[3]: Standard error
Northwest Bathurst 1 (25.5%)	18	0	4	1.7	1.4	70.5	58.4
Northeast Bathurst 2 (25.6%)	41	17	8	2.5	0.8	159.7	50.8
South Bathurst 3 (25.5%)	15	0	4	1.2	1.0	58.9	51.5
Polar Bear Pass 4 (74.3%)	0	0	0	0	0	0	0
Total (26.8%)	74	17	16	1.7	0.5	289.1	93.0

1 Figure 1.

2 Excluding caribou counted during the survey.

3 Based on the number of caribou counted during the survey within 1.6-km transects.

Table 2. Changes in estimated numbers of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from 1961 to 1981.

Survey years	Peary caribou		Muskoxen	
	Estimated number	Percentage change	Estimated number	Percentage change
1961[1]	2723		1136	
1961-73		-74%		-41%
1973[2]	712		672	
1973-74		-68%		-76%
1974[3]	231		164	
1974-81		+25%		+27%
1981[4]	289		208	
1961-81		-89%		-82%

1 Surveyed 19 June - 7 July. Muskox estimates were "provisional guesses", except for northeast and south Bathurst. Caribou estimates may have been low (Tener 1963).

2 Surveyed 19 March - 3 April. Caribou numbers estimated for July - August. Muskox numbers estimated for March - April (Miller et al. 1977a).

3 Surveyed 25-26 August (Miller et al. 1977a).

4 Surveyed 10-13 August.

al.'s August 1974 estimate. Because of the large standard errors for the 1974 (Miller et al. 1977a) and 1981 (Table 1) estimates, and the apparent variability between the two independent estimates in August 1974, wide confidence intervals are assumed. Therefore, I cautiously conclude that the caribou population size in 1981 was at least similar to that in 1974.

Fischer and Duncan (1976) surveyed Bathurst Island in April and June 1975 at relatively low coverage (8.3%). Winter surveys have intrinsic observational problems because it is difficult to see the caribou's white pelage against the snow (Miller and Russell 1975). Fischer and Duncan's (1976) April 1975 estimate of 120 can be increased to 150, if the correction factor (1.246) developed by Miller and Russell (1975) is applied to account for this observational error. Even after accounting for assumed spring mortality (7.5%, Miller and Russell 1975) and calves seen in June (35%, Fischer and Duncan 1976), the large difference in the estimates from Fischer and Duncan's April and June surveys (i.e., 188 vs. 361) suggests that the survey coverage was inadequate. Given the lack of reliable surveys between 1974 and 1981, it is unknown whether or not the population has remained stable during those years. Nevertheless, the 20-year population trend from 1961 to 1981 represents an 89% decrease.

In April 1980, Thomas and Joly (1981) conducted non-systematic reconnaissance surveys over the western QEI. Thomas and Joly did not provide an estimate of the sampling intensity

for these surveys; however, they flew only 325 km over Bathurst Island and saw only two caribou. This is not surprising, based on my August 1981 sighting density of 0.033 caribou per km and given the variability shown by the higher-coverage systematic surveys.

In about 2700 km of reconnaissance over the western QEI, Thomas and Joly (1981) observed only 10 caribou in 1980. Based on a number of assumptions, they went on to calculate a population size of 634 Peary caribou on these islands. Application of their assumptions (Thomas and Joly 1981) to Bathurst Island leads to an underestimate of about 58 caribou in 1981, probably because their assumptions of no recruitment and high adult mortality were wrong. Also in August 1981, McLaren (1981) surveyed the Bridport Inlet - Mecham River area of eastern Melville Island. Regarding Thomas and Joly's (1981) surveys, she concluded that "considerably more animals were present in 1980 than [they] suggested."

Calf Production

Calves made up 19% of observed caribou (Table 3), and the proportion of calves did not differ ($P > 0.93$) between sampling strata. The percentage of calves in 1981 did not differ ($P > 0.92$) from that in 1961 (20%, Tener 1963); while estimated populations differed by a factor of about nine. Calf production is proximately related with snow depth, ground-fast ice and

Table 3. Percentages of calves[1] among Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from an aerial survey, 10-13 August 1981.

Sampling stratum	Peary caribou			Muskoxen		
	Number of calves	Total number	Percent calves[2]	Number of calves	Total number	Percent calves[3]
Northwest Bathurst 1	4	22	18%	3	36	8%
Northeast Bathurst 2	12	66	18%	4	34	12%
South Bathurst 3	4	19	21%	19	105	18%
Polar Bear Pass 4	0	0	--	10	47	21%
Total	20	107	19%	36	222	16%

1 Includes all groups for which all calves were counted during the survey and during ferrying.

2 Strata 1 and 3 combined (because expected number of calves was less than 5) do not differ ($P > 0.93$) from stratum 2.

3 Do not differ ($P > 0.50$) between strata when considered together.

duration of snow cover during previous winters (Miller et al. 1977a, Thomas 1982). The percentage of calves was greater after the apparently mild snow conditions in winter 1980-81 (Figure 3) than after the severe winter of 1973-74, when Miller et al. (1977a) saw no calves and Fischer and Duncan (1976) saw only 5 (9%) calves among 55 caribou.

Thomas (1982) found consistently low pregnancy rates (i.e., 6-7% of adult females) in March-April of 1974, 1975 and 1976 in the western QEI. Pregnancy rates increased to 88% in March-April 1977. Pregnancy rates were closely correlated with fat reserves in adult cows in late winter. Thomas (1982) suggests that cows which lactated calves during the previous summer may not breed during the rut because of the energy stress of pregnancy and lactation. If this is true, Peary caribou could not have substantial calf production during two successive summers; a selective disadvantage during a series of relatively mild winters.

Following the severe winter of 1973-74, it supposedly took two years for caribou to recover from malnutrition (Thomas and Broughton 1978). Pregnancy rates on Bathurst Island were sampled only in 1974 when 7% of cows on Melville, Bathurst and Byam Martin islands were pregnant (Parker et al. 1975). In late June 1975, calves made up 35% of 48 caribou observed on Bathurst Island and 25% of 158 on eastern Melville Island (Fischer and Duncan 1976). Caribou apparently recovered quickly after the

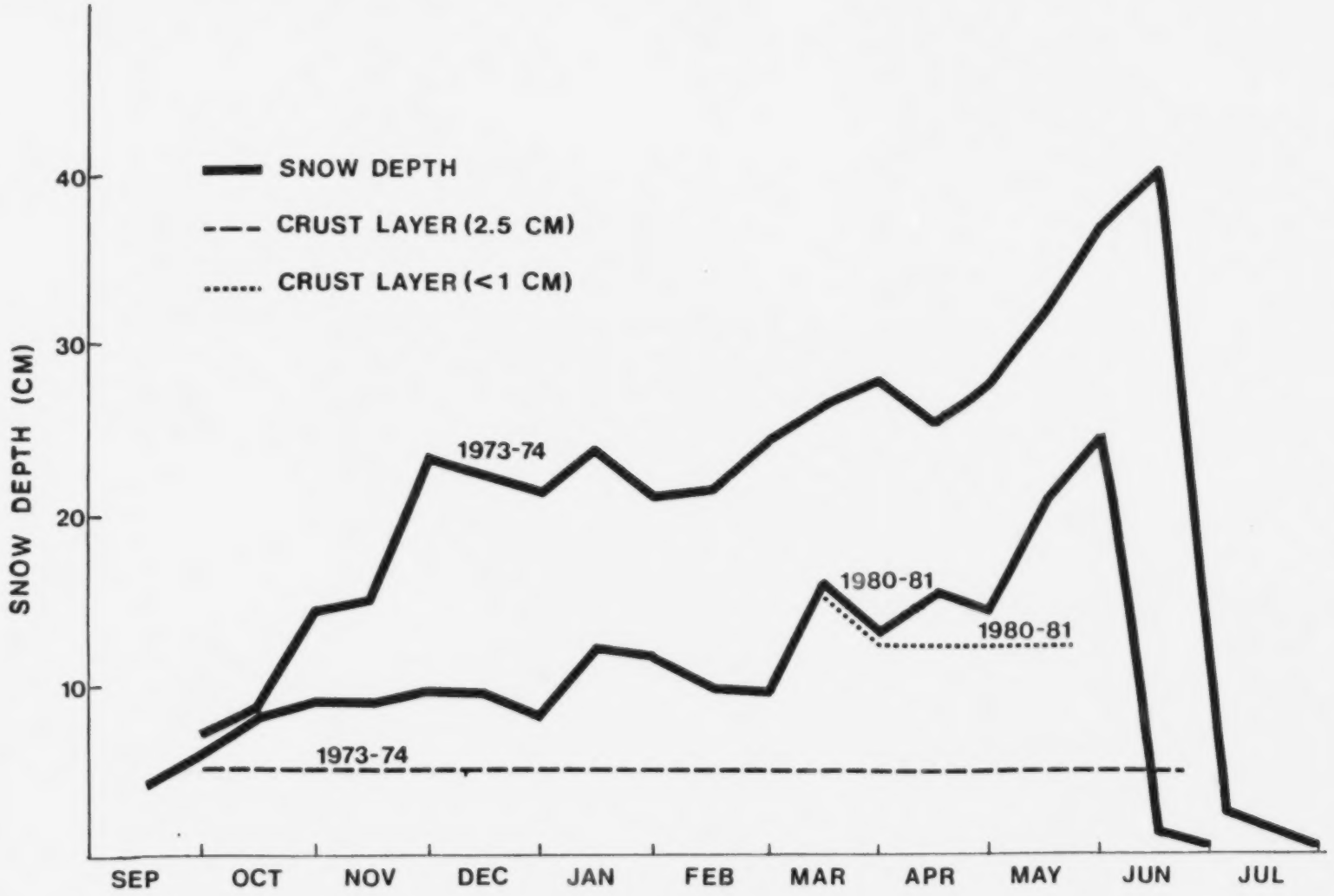

Figure 3. Snow cover conditions during the winters of 1973-74 and 1980-81 at Resolute Airport, Cornwallis Island, Northwest Territories (D. Gullet pers. comm.).

severe winter of 1973-74 on Bathurst Island (Thomas and Joly 1981) and on eastern Melville Island. Summer calf counts were not conducted in other parts of the western QEI to confirm pregnancy rates obtained by Thomas (1982) in late winter in 1974 and 1975.

The ability to recover during the summer immediately after a severe winter would be a distinct selective advantage. This might be possible if, at any point during the winter, females could respond to severe environmental conditions which would make subsequent calf survival unlikely. For example, a female with a given fat reserve might not breed in October if severe early winter conditions (e.g., freezing rain) caused foraging stress; however, she may breed given the same fat reserves and mild early winter conditions. Via other physiological events (e.g., non-conception, resorption, abortion) (Dauphine 1976), the energy demands of the third trimester of pregnancy and lactation could be avoided. To determine the factors and mechanisms affecting reproduction in Peary caribou, more research of populations with differing fat reserves under various environmental conditions is necessary.

Group Size

The average group size of caribou (solitary animals excluded) was 5.6 in early August 1981. Overall, group size increases from late winter to late summer (e.g., 2.7 in March

1974, Miller et al. 1977a; 4.7 in June-July 1961, Tener 1963; 5.6 in August 1981, and 6.4 in late August 1974, Miller et al. 1977a). The proportion of solitary animals in August 1981 was 5% of all observed groups compared to 7% in late August 1974 (Miller et al. 1977a). Caribou group size on Bathurst Island was smallest (2.7), and the relative number of solitary animals, greatest (i.e., 29% of all groups, Miller et al. 1977a), during late March 1974. Mortality and stress may directly influence group size during winters when foraging is difficult (e.g., 1973-74; Miller et al. 1977a).

In August 1981, groups on northeastern Bathurst Island may have split up to search for small, dispersed feeding sites. In the largely snow-covered northeastern area, average group size was less than that in strata 1 and 3 where caribou were found in essentially snow-free areas in August 1981 (Table 4). This dispersion of smaller groups may have been a feeding response to localized sites of little or no snow cover.

Distribution

During the period 10-13 August 1981, strata 3 and 4 (Figure 2) were utilized by caribou less than expected ($P < 0.008$); while stratum 1 held as many caribou as expected ($P > 0.56$) (Table 5). Sixty-four percent of caribou observed during the survey preferred ($P < 0.001$) stratum 2. This preference was consistent with the seasonal migrations of Bathurst Island

Table 4. Group sizes[1] of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, during an aerial survey, 10-13 August 1981.

Sampling stratum	Peary caribou				Muskoxen			
	Number of groups	Group size			Number of groups	Group size		
		Mean	Range	Standard error		Mean	Range	Standard error
Northwest Bathurst 1	3	7.3	4- 9	2.9	7	6.1	1-11	4.1
Northeast Bathurst 2	14	4.7	1- 9	2.1	6	5.7	1- 9	3.3
South Bathurst 3	3	6.3	4-11	4.0	9	11.7	1-23	6.5
Polar Bear Pass 4	0	---	----	---	4	11.8	7-17	4.6
Total	20	5.4	1-11	2.6	26	8.8	1-23	5.6

1 Includes all groups observed during the survey and during ferrying.

Table 5. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, by sampling strata, 10-13 August 1981.

Sampling stratum	Percent of total land area	Percent of total survey area[1]	Percent of observed animals[2]	
			Caribou	Muskoxen
Northwest Bathurst 1	25.3%	24.1%	19.8%	18.5%
Northeast Bathurst 2	40.5%	38.8%	63.7%[3]	18.0%[3]
South Bathurst 3	31.7%	30.2%	16.5%[3]	38.6%[3]
Polar Bear Pass 4	2.5%	6.9%	0.0%[3]	24.9%[3]

1 Differs from percent of total land area because sampling intensity differed between strata (i.e., 26% in strata 1, 2 and 3; 74% in stratum 4).

2 Includes only groups observed during the survey (i.e., 91 caribou, 189 muskoxen).

3 Differs ($P < 0.05$) from percent of total survey area.

caribou described by Inuit hunters of Resolute (Riewe 1976), Fischer and Duncan (1976) and Miller et al. (1977a).

From late June to August caribou are usually north of Polar Bear Pass (about 75°50'N, Figure 2) (Tener 1963, Fischer and Duncan 1976, Miller et al. 1977a). During early August 1981, 91% of the caribou within stratum 2 were north of 76°20'N; the most northerly concentration documented on Bathurst Island. During late August 1974, only 25% of caribou in stratum 2 were as far north (F.L. Miller pers. comm). If the migration is consistent each year, the southward movement begins during August. Caribou apparently move south across Polar Bear Pass in the fall (Fischer and Duncan 1976). During 1971-74, hunters from Resolute began harvesting caribou south of Polar Bear Pass during the fall (Freeman 1975). Bathurst Island caribou winter south of Polar Bear Pass and migrate north between late March and late May (Fischer and Duncan 1976, Riewe 1976, Miller et al. 1977a). In early April 1973, caribou were concentrated just south of Polar Bear Pass (Miller et al. 1977a). By late May 1974, only 2 caribou were found on southern Bathurst Island (Fischer and Duncan 1976). In late June - early July 1961, the population was north of Polar Bear Pass (Tener 1963), where calving probably occurs. The winter range is about 145 km south of the most northern concentration which occurs during August. This migratory pattern was evident only on the eastern three-quarters of the island.

Bathurst Island caribou preferred ($P < 0.001$) elevations between 151 and 300 m ASL in August 1981 (Table 6), although they tended to be at lower elevations within that zone (overall median, 152 m). Caribou were not found below 60 m, and were found less frequently than expected between 60 and 150 m ($P < 0.035$). In late August 1974, caribou also preferred the 151-300 m zone (Miller et al. 1977a). Differences in topographical preferences of caribou are apparent between summer and late winter. Caribou showed strongest preferences for the 60-300 m zone in March-April 1973; and for areas below 60 m and between 151 and 300 m in March 1974 (Miller et al. 1977a). Reduced use of higher elevations from summer to winter coincides with the fall migration into southeastern Bathurst Island where higher elevations occupy only 25% of the land versus 50% in the northeast. Nevertheless preference was shown for higher land within the seasonal ranges, even in winter.

Caribou preferred ($P < 0.035$) to be from 2.5 to 10 km from the coast (overall median, 6.5 km) in early August 1981 (Table 7). No caribou occurred at distances closer than 2.5 km from the coast; and they occurred less than expected ($P < 0.008$) between 10 and 15 km, and as expected ($P > 0.77$) farther than 15 km from the coast. In late August 1974 preferences were shown for areas 2.5 to 15 km from the coast (Miller et al. 1977a). The absence of caribou within 2.5 km of the coast in August 1974

Table 6. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, by elevational zones, 10-13 August 1981.

Elevation above sea level	Percent of total land area	Percent of total survey area[1]	Percent of observed animals[2]	
			Caribou	Muskoxen
< 60 m	25.8%	27.8%	0.0%[3]	34.9%[3]
60-150 m	38.0%	37.6%	26.4%[3]	65.1%[3]
151-300 m	35.9%	34.4%	73.6%[3]	0.0%[3]
> 300 m	0.3%	0.2%	0.0%[4]	0.0%[4]

1 Differs from percent of total land area because sampling intensity differed between strata (i.e., 26% in strata 1, 2 and 3; 74% in stratum 4).

2 Includes only groups observed during the survey (i.e., 91 caribou, 189 muskoxen).

3 Differs ($P < 0.05$) from percent of total survey area.

4 Difference from percent of total survey area was not tested because the expected number of animals was less than 5.

Table 7. Distribution of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, by distance from the seacoast, 10-13 August 1981.

Distance from seacoast	Percent of total land area	Percent of total survey area[1]	Percent of observed animals[2]	
			Caribou	Muskoxen
< 2.5 km	24.6%	25.3%	0.0%[3]	14.3%[3]
2.5-5.0 km	18.9%	19.2%	42.8%[3]	33.9%[3]
5.1-10.0 km	29.4%	29.1%	39.6%[3]	22.2%[3]
10.1-15.0 km	16.1%	15.9%	5.5%[3]	25.4%[3]
> 15.0 km	11.0%	10.5%	12.1%	4.2%[3]

1 Differs from percent of total land area because sampling intensity differed between strata (i.e., 26% in strata 1, 2 and 3; 74% in stratum 4).

2 Includes only groups observed during the survey (i.e., 91 caribou, 189 muskoxen).

3 Differs ($P < 0.05$) from percent of total survey area.

and 1981 differed from the coastal affinity detected in June-July 1961 (Tener 1963).

Bathurst Island caribou may prefer low, coastal areas during calving and early summer (Miller et al. 1977a). Since lower elevations normally become snow-free earlier, such a preference would be expected during this critical period. Miller et al. (1977a) detected strong preference for areas greater than 15 km from the coast and limited preference of the 10-15 km zone in March-April 1973. In March 1974 weak preference was suggested for areas greater than 10 km from the coast. During the severe winter of 1974 caribou used areas within 5 km of the coast about as frequently as expected (vs. less than expected in winter 1973) (Miller et al. 1977a). Locations of dropped antlers observed in August 1981 and by Fischer and Duncan (1976) suggest that caribou also prefer low, coastal areas after the rut. Bathurst Island caribou apparently increase their use of low, coastal sites during periods of physiological or foraging stress.

Although inter-island movements of Peary caribou have been studied west and south of Bathurst Island (Miller et al. 1977b, Miller and Gunn 1978), relatively little is known about the interchange of caribou between Bathurst and other islands (e.g., the possibility of movements between Bathurst and Melville islands). Miller and Gunn (1978) reported some evidence of caribou movements from Prince of Wales Island north to Bathurst

Island across Barrow Strait. Best known are movements between Bathurst and Cornwallis islands. During the early 1970s, Inuit hunters noted greater numbers of caribou on southeastern Cornwallis Island during the fall and winter, and a concurrent decrease on Bathurst Island (Freeman 1975). They became concerned that oil exploration had caused a movement of caribou from Bathurst Island to Cornwallis Island; however, the causes are debatable. Miller and Gunn (1978) suggest that difficult foraging under severe winter conditions may stimulate such movements. Inuit hunters apparently believe that caribou have moved between Bathurst and Cornwallis islands during most winters since the early 1970s, but the regularity and magnitude of these movements is uncertain (J. Stevenson pers. comm.).

Muskoxen

Population Size and Trends

During 10-13 August 1981, the population estimate of 208 muskoxen was less than the minimum number counted. Unfortunately, a confidence interval for the estimate could not be determined because of non-normal data distribution. At least 229 muskoxen were observed during ferry flights and the survey itself; of which only 37% were within the 1.6-km transects (Table 8). To obtain this minimum count, I eliminated any group which was within 2 km of any other group observed on a previous

Table 8. Numbers and densities of muskoxen on Bathurst Island, Northwest Territories, from an aerial survey, 10-13 August 1981.

Sampling stratum[1] (Sampling intensity)	Number of muskoxen counted			Number of muskoxen per 100 sq km[3]		Estimated number of muskoxen[3]	
	During survey		During ferrying[2]	Mean	Standard error	Total	Standard error
	Within 1.6-km transects	Outside transects					
Northwest Bathurst 1 (25.5%)	12	23	8	1.2	0.9	47.0	35.4
Northeast Bathurst 2 (25.6%)	8	26	0	0.5	0.4	31.2	23.3
South Bathurst 3 (25.5%)	17	56	32	1.3	0.8	66.7	41.6
Polar Bear Pass 4 (74.3%)	47	0	0	15.7	0.3	63.2	1.3
Total (26.8%)	84	105	40	2.0	0.5	208.2	59.4

1 Figure 1.

2 Excluding muskoxen counted during the survey.

3 Based on the number of muskoxen counted during the survey within 1.6-km transects.

day, if the groups had equal numbers of calves and older muskoxen. The higher count of 229 resulted from muskoxen observed during extensive ferrying over stratum 3, and 74% sampling of stratum 4 (Figure 2). Strata 3 and 4 held 64% of all muskoxen observed during the survey, compared to only 16% of observed caribou. Because of their dark colour, muskoxen were more readily seen from greater distances than caribou. During the survey, 56% of observed muskoxen were outside the strip-transects; compared with only 19% of observed caribou. Thus, a large proportion of the Bathurst Island muskox population was apparently observed during 10-13 August 1981. Fischer and Duncan (1976) also observed more muskoxen than they estimated, during surveys (8-11% coverage) over Bathurst and Melville islands in June 1975.

The Bathurst Island muskox population fell by about 40% between June-July 1961 and March-April 1973 (Tener 1963, Miller et al. 1977a) (Table 2). Miller et al. (1977a) reported an additional decline from 672 in March-April 1973 to 164 in 25-26 August 1974. Immediately prior to Miller et al.'s August 1974 survey, Fischer and Duncan (1976) estimated that 246 muskoxen were on Bathurst Island and smaller islands to the north and west during 18-25 August 1974. Only about 5% of the muskoxen observed on and off transect during Fischer and Duncan's survey were on the smaller islands near Bathurst Island. Sampling intensity differed between the two surveys. Fischer and Duncan

(1976) covered 26.8% of the entire island. Miller and Russell (1975) varied their coverage between strata; 25% south of Polar Bear Pass, 16% in northeastern Bathurst and 12.5% in northwestern Bathurst Island. Miller et al. (1977a) and Fischer and Duncan (1976) also reported different distributions of muskoxen. It is not valid to test whether or not the two estimates for August 1974 differ statistically, because of non-normal data distributions. Nevertheless, the apparent difference could have resulted from a combination of the following factors: a) differences in sampling intensities relative to muskox distribution, b) differences in visibility or observer biases, or c) a sudden change in actual muskox distribution between surveys.

If the August 1981 estimate of 208 muskoxen is compared to Miller et al.'s (1977a) estimate for August 1974, an increase of 27% is suggested (Table 2); however, comparison with Fischer and Duncan's (1976) estimate suggests a 12% decrease, after allowing for about 5% of their estimate on the smaller islands. As stated above, the estimates cannot be compared statistically. Considering the minimum count of 229 in 1981 and the variability of the 1974 estimates, I conclude that the muskox population on Bathurst Island probably stabilized between 1974 and 1981. Nevertheless, the 1981 population was still 82% less than that in 1961.

The muskox populations of the western QEI apparently increased between 1961 and 1973 (Tener 1963, Miller et al. 1977a). In contrast, the muskox population on Bathurst Island apparently dropped by about 40% (Table 2). In 1974 Bathurst Island muskoxen made up only 6% of the population on the western QEI (Miller et al. 1977a).

Population decreases were highly variable (i.e., 25 - 100%) between islands surveyed in 1973 and 1974 (Miller et al. 1977a). Muskoxen are apparently affected by local habitat and weather conditions, probably because of their relatively sedentary habits. The low amount of preferred forage in diets of Bathurst Island caribou and muskoxen in 1974 and 1975 suggested that their range deteriorated from overuse during the 1960s (Parker 1978). If this were true, this population may have been particularly sensitive to forage unavailability during severe winters.

Muskoxen densities (12/100 sq km) in Polar Bear Pass in early August 1981 were considerably less than those along the Thomsen and Parker rivers, Banks Island in 1980 (93 and 73/100 sq km, Vincent and Gunn 1981), and in the Bailey Point region, Melville Island from 1972 to 1980 (60 - 110/100 sq km, Thomas et al. 1981). However, during behavioral studies, Gray (1973) observed an increase of approximately 500% in muskox numbers between mid-August and early October in Polar Bear Pass in 1970 and 1971. Polar Bear Pass may be important for the survival of

the Bathurst Island muskox population. However, available data do not indicate that the Pass merits special recognition for its muskox habitat alone, if compared to other muskox refugia in the arctic islands.

Calf Production

In August 1981, 16% of 222 classified muskoxen were calves (Table 3). The proportion of calves in 1981 apparently did not differ ($P > 0.09$) from the 9% observed during aerial surveys in 1961 ($n = 111$, Tener 1963). The proportion of muskox calves has varied greatly between years; apparently regulated by winter weather conditions. Gray (1973) observed no calves, yearlings or 2-year olds from 1968 to 1970 in Polar Bear Pass. Incomplete breeding activity, probably caused by poor physical condition, appeared responsible for this low calf production. The presence of calves in 1971 and complete courtship behaviour indicated a return to breeding condition in 1970. Gray (in Parker et al. 1975) saw 27 calves among 108 muskoxen in Polar Bear Pass during summer 1973. Fischer and Duncan (1976) saw only one calf among 135 muskoxen on the south and west coast of the island in late June 1974; while in August 1974 Miller et al. (1977a) found no calves on Bathurst Island. Therefore, calf production and/or survival was generally poor from 1967 to 1974. Parker et al. (1975) found very low marrow fat reserves in dead muskoxen in late winter 1974 on Bathurst Island; indicating death by

starvation following that severe winter. Calf production apparently was higher in 1975 as 7 calves (10%) were observed among 69 muskoxen classified in late June (Fischer and Duncan 1976).

During a 1961 ground survey, Tener (1963) found 28% calves among 4 muskox herds (n = 69) at Bracebridge Inlet; which differed ($P < 0.004$) from the 9% calves observed during his 1961 aerial survey over the entire island. He suggested that the higher proportion of muskox calves near Bracebridge Inlet, and some evidence of twinning and calves in successive years probably reflected excellent forage available in that area. The proportion of calves in central and southern Bathurst Island in 1981 was higher than in northern portions of the island, although not significantly so ($P > 0.50$) (Table 3). These observations suggest that better summer forage and/or wintering conditions for muskoxen exist on southern and central Bathurst Island.

Group Size

In August 1981 the average group size of muskoxen on Bathurst Island was 10.2 with solitary animals excluded, and 8.8 with those individuals included (Table 4). Solitary muskoxen made up 15% of the 26 groups observed in August 1981. Muskoxen groups usually decrease in size between late winter and summer; peaking in April and reaching a low in July-August (Gray 1973).

Group size averaged 13.9 in March-April 1973 when no solitary muskoxen were observed (Miller et al. 1977a). However, in late March 1974 average group size (excluding solitary animals) was only 6.9, and solitary muskoxen made up 17% of the 48 groups observed (Miller et al. 1977a). The unusually small group size and large proportion of solitary animals in March 1974 was apparently a function of severe snow conditions, which forced muskoxen from preferred lowland sites to windswept ridges and knolls where small exposed sites could not support large groups (Miller et al. 1977a). Mortality and "intra-group stress" (i.e., stress within groups which may lead to intolerance and fragmentation of groups) may have been ultimately responsible for group fragmentation (Miller et al. 1977a). The effects of mortality and stress on group patterns were still evident in August 1974 when Miller et al. (1977a) found an average group size (singles excluded) of 4.0 (cf. 10.2 in August 1981).

In August 1981, average group sizes in southern Bathurst Island and Polar Bear Pass were almost twice those in northeastern and northwestern Bathurst Island (Table 4). Under severe winter conditions in March 1974, average group sizes on southern Bathurst Island were also twice those on the remainder of the island (Miller and Russell 1976). The larger group sizes, and higher proportions of calves among muskoxen in preferred southern and central Bathurst Island, suggest that these areas may be more conducive to winter survival, and calf

production and/or survival. Preferred muskoxen habitat appears to be more prevalent in central and southern Bathurst Island than in the north (R. Decker pers. comm.). Mortality and intra-group stress which cause group fragmentation may be less severe in these areas.

Distribution

Muskoxen preferred ($P < 0.008$) southern Bathurst Island and Polar Bear Pass in August 1981 (Table 5). Muskoxen occurred less than expected ($P < 0.001$) in northeastern Bathurst Island and as expected ($P > 0.10$) in the northwestern part of the island. These findings, and those of Tener (1963), Fischer and Duncan (1976) and Miller et al. (1977a), suggest that muskoxen consistently prefer southern and central Bathurst Island; without seasonal changes in distribution as large as those shown by Bathurst Island caribou.

As noted earlier, muskox occurrence in northern Bathurst Island apparently changed between consecutive surveys during 18-25 August (Fischer and Duncan 1976) and 25-26 August 1974 (Miller et al. 1977a). Fischer and Duncan (1976) surveyed Bathurst and smaller islands, to the northeast and north, at 26.8% coverage. However, in the later survey, coverage varied between strata on Bathurst Island (Miller and Russell 1975). Fischer and Duncan (1976) observed only 20% of the population north of Bracebridge and Goodsir inlets. On the other hand,

Miller et al. (1977a) estimated that 48% of the population was on northeastern Bathurst Island. This difference could possibly reflect the different sampling intensities and differing degrees of coincidence between transect placements and the few muskox groups. Alternatively, it is possible that this difference was caused by an actual movement of muskoxen from just south to just north of Bracebridge Inlet. Fischer and Duncan (1976) indicated that 1 of 3 groups observed in northeastern Bathurst Island were just north of Bracebridge Inlet; while Miller et al. (1977a) showed that 3 of 6 groups were there. Ground observations by Gray (1974) indicated that muskox herds hold a defence formation while an aircraft is overhead, but often stampede out of the area after it has flown past. Such movements can result in herds leaving feeding areas (Gray 1974). The aerial survey by Fischer and Duncan (1976) may have caused a movement of muskoxen across the strata boundary. From 18 to 25 August 1974, survey altitude was 90 m AGL using a Dornier D. O. 28 (Fischer and Duncan 1976). Miller and Gunn (1979) have shown that during helicopter overflights below 200 m AGL, muskoxen cantered, galloped or formed group defense formations more often than expected.

Although muskoxen consistently preferred southern and central Bathurst Island in all seasons, Gray (1973) detected seasonal changes in muskoxen distribution within Polar Bear Pass during 1968-71. Low numbers of muskoxen occurred in Polar Bear

Pass during late winter, spring and early summer. Herds moved into the valley during July and August. A late summer influx into the wetter lowlands coincides with the end of the rut and may be affected by early snowfalls permanently covering higher elevations as early as late August. During October and November 1970, herds left the valley and no muskoxen were observed from late November to early February 1971. Hubert (1974) also observed local seasonal changes in muskox distribution in the Truelove Lowland, Devon Island.

Local seasonal movements by muskoxen on Bathurst Island were also evident from aerial surveys in 1973, 1974 (Miller et al. 1977a) and 1981. Although Bathurst Island muskoxen preferred areas within 2.5 km of the coast and elevations below 60 m ASL in the late winters of 1973 and 1974, this preference for low, coastal areas was greatest during the severe winter of 1974 (Miller et al. 1977a). Preference for somewhat higher, more inland areas apparently increases until early August. In early August 1981, muskoxen preferred ($P < 0.001$) areas 2.5-5 km and 10.1-15 km from the Bathurst Island coast (overall median, 7 km; Table 7). Sites under 2.5 km, 5.1-10 km and over 15 km from the coast were utilized less than expected ($P < 0.045$) by muskoxen. At the same time, muskoxen preferred ($P < 0.001$) elevations below 151 m ASL; with none occurring above 150 m (overall median, 61 m; Table 6). In late August 1974, approximately 40% of observed muskoxen were within 2.5 km of the

coast; and over 70% preferred elevations less than 60 m ASL (Miller et al. 1977a). These observations suggest that Bathurst Island muskoxen move inland along streams between late winter and mid-summer, and then back towards the coast during mid-August. These August movements generally correspond with the influx of muskoxen into the Polar Bear Pass lowlands in late summer (Gray 1973).

Range Overlap and Potential for Competition

In mid-summer 1981, preferences by caribou and muskoxen for different distances from the coast, and especially for different elevations and strata on Bathurst Island, suggested little range overlap. Similar preferences determined by Miller et al. (1977a) in late August 1974 also suggested little overlap. Range overlap during caribou calving is also probably limited since caribou apparently calve north of Polar Bear Pass, an area which generally is not preferred by muskoxen. However, the potential for overlap during and/or after the caribou rut may be greater. Seven of 12 dropped caribou antlers observed during the 1981 survey were at low elevations along the southwest coast; preferred muskox habitat. In severe winters there may be some potential range overlap. In the severe winter of 1974, caribou preferred low elevations on southern Bathurst Island, and a greater proportion were near the coast than in the winter

of 1973 (Miller et al. 1977a); however, Miller et al. detected no clear preference of coastal areas by caribou. The apparently limited range overlap indirectly supports concerns of hunters of Sachs Harbour, Banks Island "...that caribou are repelled by the musky odour of muskoxen" (Vincent and Gunn 1981: 178). On the other hand, Gray (1973) noted that both caribou and muskoxen were often observed grazing within 100 m or less without any noticeable interaction.

I suspect that there is usually little opportunity for competition between Bathurst Island caribou and muskoxen, given the limited evidence of range overlap. However, on poor range, competition may occur and may contribute to mortality during severe winters, when muskoxen are forced from meadows to feed on willow, grasses and forbs on exposed ridges and slopes (Parker 1978). Parker (1978) stated that the low proportion of willow in the diets of Bathurst Island caribou and muskoxen in 1974 and 1975 suggested that willow was not as abundant on Bathurst Island as on other arctic islands. He also suggested that the low incidence of preferred forage may reflect range deterioration from past high densities of both species. Conversely, despite range overlap, interspecific competition between Peary caribou and muskoxen is usually considered to be negligible (Gray 1973, Miller et al. 1977a, Parker 1978). Competition between caribou and muskoxen on Bathurst Island currently cannot be supported by any conclusive evidence, but

may warrant further investigation. Management of caribou and muskoxen to prevent over-use of their ranges may prevent competition (Vincent and Gunn 1981).

Management and Study Implications

Although Bathurst, Prince of Wales and Somerset islands hold only about 25% of all Peary caribou (Appendix A), the caribou on these islands are disproportionately important due to their utilization by residents of Resolute and Grise Fiord. Bathurst Island, being the most accessible, was the caribou-harvesting centre for hunters from Resolute from 1962 to 1974 (Riewe 1976), and remains a focus for future harvesting. The future of Peary caribou on Bathurst Island is difficult to predict. Since 1974, hunters from Resolute have not harvested caribou from the island, and oil and mineral exploration has been limited; however, no substantial increase has been detected as of 1981.

Many potential dangers will continue to threaten this population. Severe winters every second or third year could essentially eliminate calf production and/or cause severe mortality due to forage unavailability. The effects of past over-grazing may prohibit foraging of plant species which are efficiently utilized by caribou (Parker 1978). Resumption of harvesting activity would have direct and immediate effects on

the population. Year-round tanker traffic through Barrow Strait or other waters could disrupt, and possibly eliminate, potential immigration of caribou to Bathurst Island from Prince of Wales (Miller and Gunn 1978) or Melville islands. A pipeline from north to south across the island could interrupt any east-west inter-change of caribou, or possibly affect seasonal migrations of caribou on the island. Other land use may have as yet unmeasured effects on productivity and survival of caribou through long-term range abandonment and stress due to avoidance or flight behaviour (Miller and Gunn 1979). The impact of wolf predation has not been studied, but wolf populations north of 74°N are considered to be low (Gunn et al. 1981).

Based on the 1981 population estimate, harvesting of caribou should not yet resume on Bathurst Island. There is no strong evidence of a population increase since 1974. Population surveys should be conducted on a regular basis every 5 years to evaluate population trends, and to determine whether or not harvesting should resume. Caribou on Prince of Wales and Somerset islands will probably remain the principle source of caribou meat for residents of Resolute. After observing numbers of caribou on southern Bathurst Island while harvesting other species in spring 1984, the Resolute Hunters and Trappers Association (HTA) requested advice on whether or not hunting should resume (R. Hagen pers. comm.). When told that it should not, the HTA agreed to follow this advice.

The evidence of caribou movements between Bathurst and Cornwallis islands was discussed with the Resolute HTA during 1981 and 1982 (J. Stevenson pers. comm.). Based on the limited available evidence, the islands apparently hold one population. As a result, the Resolute HTA extended their ban on caribou harvesting by Inuit from Bathurst to Cornwallis and interjacent islands. The Department of Renewable Resources should similarly prohibit caribou harvesting by non-Inuit on these same islands. Efforts should also be made to monitor caribou numbers on Cornwallis Island in the future.

To define the population boundaries of Bathurst Island caribou properly, movements within the Melville - Bathurst - Cornwallis - Prince of Wales islands complex should be investigated over a number of years. The regularity, directions, frequencies and magnitude of any such movements would also provide baseline information to help evaluate the potential impacts of pipelines and/or winter oil tanker and other shipping traffic.

Miller et al. (1977a) recommended that muskox harvesting on the western QEI be restricted to 1% of the estimated 1974 population until increases are determined. This would have allowed a largely meaningless harvest of 2 muskoxen from Bathurst Island. Since there is no strong evidence of an

increase in population since 1974, I recommend that there be no muskox harvesting on Bathurst Island before an increase is evident.

The August 1981 survey revealed inadequacies caused by compromises made to census Peary caribou and muskoxen simultaneously. These inadequacies were especially evident from the estimated number of muskoxen being lower than the minimum count, and from the inability to provide valid confidence intervals for the estimated numbers of caribou and muskoxen. For small, clumped populations, the use of normal statistics for population estimates will remain invalid. As well, given expected budget restraints, the requirement for simultaneous censuses of both species is expected to continue.

Any unexpected distribution changes prior to a given survey could result in a gross underestimation of such populations, if stratification and sampling intensities are determined in advance. Therefore, I recommend a 25% survey of the entire land mass. Then, areas of caribou or muskoxen concentration should be sampled intensively, as was done over Polar Bear Pass in 1981. In such areas, with sampling approaching 100% (i.e., actually about 75% because of the blind zone below the aircraft), population estimates coupled with high minimum counts can provide reliable information for management decisions.

The 1.6-km strip-transect appeared to be adequate. The Cessna 337 aircraft also proved adequate, but its relatively high minimum speed may be a disadvantage in other areas where high densities of animals occur. Its fast cruising speed, however, is an economic advantage where long ferry flights are required, as in the 1981 survey. A survey altitude of 150 m AGL, recommended for caribou surveys by Miller et al. (1977a), should be used in surveys of both species over Bathurst Island.

Future surveys should be conducted during late July or early August. Surveys slightly earlier than the 10-13 August 1981 survey should avoid problems of early snow accumulation at higher elevations, while allowing comparisons of distribution and proportions of calves between years.

RECOMMENDATIONS

Note: The following recommendations come from research results up to 1981. Since then, additional studies have resulted in revised recommendations concerning the harvesting of caribou and muskoxen on Bathurst Island. The new studies and revised harvesting recommendations will be presented elsewhere.

1. Harvesting of caribou should not yet resume on Bathurst Island.
2. Caribou population surveys should be conducted every five years to estimate population size, and to determine when, and if, harvesting should occur. Efforts should also be made to monitor caribou numbers on Cornwallis Island.
3. The Department of Renewable Resources should prohibit caribou harvesting by non-Inuit on Cornwallis Island and islands between Bathurst and Cornwallis islands.
4. To define the population boundaries of Bathurst Island caribou properly, movements within the Melville - Bathurst - Cornwallis - Prince of Wales islands complex should be investigated over a number of years.
5. No harvesting of muskoxen should occur on Bathurst Island before an increase is evident.
6. Aerial surveys of caribou and muskoxen on Bathurst Island should sample 25% of the entire land area. Then areas of caribou or muskox concentration should be sampled intensively (i.e., approaching 100% coverage). Aerial surveys should be flown at an altitude of 150 m AGL.

Future surveys should be conducted during late July or early August.

ACKNOWLEDGEMENTS

I gratefully acknowledge the field assistance of R. Decker, survey observer; and L. Buckmaster, pilot, Landa Aviation. G. Eckalook, Resolute Hunters and Trappers Association; and J. Stevenson and P. Gray, Department of Renewable Resources acted as observers/navigators during different portions of the survey. The Arctic Land Use Research Project provided some funding for the survey, and A. Gunn assisted with survey design. I also thank R. Decker, M.A. Ferguson, P. Gray, A. Gunn, D. Heard, D. Melton, K. Poole, B. Stephenson, A. Welch and B. Wooley for their helpful comments on the manuscript.

PERSONAL COMMUNICATIONS

Decker, R. — Resource Development Officer, Department of Renewable Resources, Government of the NWT, Yellowknife, NWT.

Gullet, D. — Weather Information, Atmospheric Environment, Environment Canada, Downsview, Ontario.

Gunn, A. — Regional Wildlife Biologist, Department of Renewable Resources, Government of the NWT, Coppermine, NWT.

Hagen, R. — Renewable Resources Officer, Department of Renewable Resources, Government of the NWT, Norman Wells, NWT.

Miller, F.L. — Research Scientist, Canadian Wildlife Service, Edmonton, Alberta.

Stevenson, J. — Assistant Regional Superintendent, Department of Renewable Resources, Government of the NWT, Coppermine, NWT.

LITERATURE CITED

Cochran, W.G. 1963. Sampling Techniques. Wiley and Sons, New York. 413 pp.

Dauphine, T.C., Jr. 1976. Biology of the Kaminuriak population of barren-ground caribou. Part 4: Growth, reproduction and energy reserves. Can. Wildl. Serv. Rep. Ser. No. 38. 71 pp.

Fischer, C.A. and E.A. Duncan. 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin, 1975. Rep. prep. for Polar Gas Environ. Prog. by Renewable Resources Consulting Services Ltd. 194 pp.

Freeman, M.M.R. 1975. Assessing movement in an arctic caribou population. J. Environ. Manage. 3: 251-257.

Gray, D.R. 1973. Social organization and behaviour of muskoxen (Ovibos moschatus) on Bathurst Island, N.W.T. Ph. D. Thesis, Univ. Alberta, Edmonton. 212 pp.

Gray, D.R. 1974. The defence formation of the musk-ox. Musk-ox 14: 25-29.

Gunn, A. and R. Decker. 1984. Numbers and distributions of Peary caribou and muskoxen in July 1980 on Prince of Wales, Russell and Somerset islands, N.W.T. N.W.T. Wildl. Serv. unpubl. File Report No. 38. 56 pp.

Gunn, A., F.L. Miller and D.C. Thomas. 1981. The current status and future of Peary caribou Rangifer tarandus pearyi on the arctic islands of Canada. Biol. Conserv. 19: 283-296.

Hubert, B. 1974. Estimated productivity of muskox (Ovibos moschatus) on northeastern Devon Island, N.W.T. M.S. Thesis, Univ. Manitoba, Winnipeg. 118 pp.

Jakimchuk, R.D. and D.R. Carruthers. 1980. Caribou and muskoxen on Victoria Island. Rep. prep. for Polar Gas Project by R.D. Jakimchuk Management Associates Ltd., Sidney, B.C. 93 pp.

McLaren, M.A. 1981. A study of muskox behaviour and distribution during early rut on eastern Melville Island, August 1981. Rep. prep. for Arctic Pilot Project by LGL Ltd., Toronto. 74 pp.

Miller, F.L. and A. Gunn. 1978. Inter-island movements of Peary caribou south of Viscount Melville Sound, Northwest Territories. Can. Field-Nat. 92(4): 327-331. (Supplementary information and viewpoints pp. 331-333).

Miller, F.L. and A. Gunn. 1979. Responses of Peary caribou and muskoxen to turbo-helicopter harassment, Prince of Wales Island, Northwest Territories, 1976-77. Can. Wildl. Serv. Occ. Pap. No. 40. 90 pp.

Miller, F.L. and R.H. Russell. 1975. Aerial surveys of Peary caribou and muskoxen on Bathurst Island, Northwest Territories, 1973 and 1974. Can. Wildl. Serv. Prog. Notes No. 44. 8 pp.

Miller, F.L. and R.H. Russell. 1976. Distributions, movements and numbers of Peary caribou and muskoxen on western Queen Elizabeth Islands, Northwest Territories, 1972-74. Can. Wildl. Serv. unpubl. rep. CWSC 2045. 493 pp.

Miller, F.L., R.H. Russell and A. Gunn. 1975. The recent decline of Peary caribou on western Queen Elizabeth Islands of arctic Canada. Polarforschung 45: 17-21.

Miller, F.L., R.H. Russell and A. Gunn. 1977[a]. Distributions, movements and numbers of Peary caribou and muskoxen on western Queen Elizabeth Islands, Northwest Territories, 1972-74. Can. Wildl. Serv. Rep. Ser. No. 40. 55 pp.

Miller, F.L., R.H. Russell and A. Gunn. 1977[b]. Interisland movements of Peary caribou (Rangifer tarandus pearyi) on western Queen Elizabeth Islands, arctic Canada. Can. J. Zool. 55: 1029-1037.

Nettleship, D.N. and P.A. Smith (eds.). 1975. Ecological sites in northern Canada. Can. Com. Internat. Biol. Prog., Ottawa. 330 pp.

Parker, G.R. 1978. The diets of muskoxen and Peary caribou on some islands in the Canadian High Arctic. Can. Wildl. Serv. Occ. Pap. No. 35. 21 pp.

Parker, G.R., D.C. Thomas, E. Broughton and D.R. Gray. 1975. Crashes of muskox and Peary caribou populations in 1973-74 on the Parry Islands, arctic Canada. Can. Wildl. Serv. Prog. Notes No. 56. 10 pp.

Porsild, A.E. 1955. The vascular plants of the western Canadian Arctic Archipelago. Nat. Mus. Can. Bull. No. 135, Biol. Ser. No. 45. 226 pp.

Riewe, R. 1976. Inuit land use in the High Canadian Arctic. In: M.M.R. Freeman (ed.). Inuit land use and occupancy project. Volume one: Land use and occupancy. Indian and Northern Affairs Canada, Ottawa. pp. 173-184.

Tener, J.S. 1963. Queen Elizabeth Islands game survey, 1961. Can. Wildl. Serv. Occ. Pap. No. 4. 50 pp.

Thomas, D.C. 1982. The relationship between fertility and fat reserves of Peary caribou. Can. J. Zool. 60: 597-602.

Thomas, D.C. and E. Broughton. 1978. Status of three Canadian caribou populations north of 70° in winter 1977. Can. Wildl. Serv. Prog. Notes No. 85. 12 pp.

Thomas, D.C. and P. Joly. 1981. Status of Peary caribou on the western Queen Elizabeth Islands in April 1980. Musk-ox 28: 58-64.

Thomas, D.C., F.L. Miller, R.H. Russell and G.R. Parker. 1981. The Bailey Point region and other muskox refugia in the Canadian Arctic: a short review. Arctic 34: 34-36.

Vincent, D. and A. Gunn. 1981. Population increase of muskoxen on Banks Island and implications for competition with Peary caribou. Arctic 34: 175-179.

APPENDIX A: Population Estimates for Peary Caribou in the Canadian Arctic

Gunn et al. (1981: 228) stated that "There are only about 10,000-15,000 Peary caribou currently (1980) inhabiting the Arctic islands..." However, they did not explain the calculation of this estimate. Addition of the most recent estimates from various surveys between 1961 and 1975, as cited by Gunn et al. (1981), suggests that there were about 19,000 Peary caribou. The following suggests a higher estimate, while explaining its calculation and assumptions.

In 1961 Tener (1963) estimated that 25,845 Peary caribou occupied the Queen Elizabeth Islands (QEI); 24,320 of which were on western islands that were surveyed by Miller et al. (1977a) between 1972 and 1974. Among the western QEI, Bathurst Island held 11% of the caribou in 1961. Between 1961 and 1974 the caribou population of the western QEI declined 89% (Miller et al. 1977), compared to 92% on Bathurst Island (Table 2). Thus, in 1974 the Bathurst Island population made up 9% of Peary caribou on the western QEI. Based on these percentages of caribou on Bathurst Island in 1961 and 1974, the western QEI population in 1981 could be estimated at 2,580 - 3,350 caribou. Further extrapolation for all QEI, based on the percentage of caribou on the western islands in 1961, must be interpreted with

considerable caution, but suggests a 1981 estimate of 2,740 - 3,560. The above extrapolations assume that the relative distributions of caribou in 1981 did not differ from those in 1961 and 1974.

Peary caribou on the QEI probably represent the purest populations of the sub-species (A. Gunn pers. comm.). The degree of genetic interchange between R. t. pearyi and R. t. groenlandicus on the southern islands of the Arctic Archipelago is not known. The purest southern populations of Peary caribou probably occur on Banks, northern Victoria, Stefansson, Prince of Wales, Russell and Somerset islands (A. Gunn pers. comm.). Latour (pers. comm. in Gunn and Decker 1984) estimated about 7,500 Peary caribou on Banks Island in June 1982. Jakimchuk and Carruthers (1980) produced an estimate of 6,250 caribou in August 1980 on Victoria Island, north of Prince Albert Sound and west of Hadley Bay. About 5,100 caribou were on Prince of Wales, Russell and Somerset islands in the summer of 1980 (Gunn and Decker 1984). These estimates, plus the extrapolated population of about 3,000 on the QEI, suggests a Peary caribou population of about 21,850, depending on the proportion of R. t. groenlandicus and cross-breeds.

Appendix B. Numbers of Peary caribou and muskoxen counted within 1.6-km strip-transects in sampling strata on Bathurst Island, Northwest Territories, 10-13 August 1981.

Stratum / Transect number	Transect area (sq km)	Number of caribou			Number of muskoxen		
		Calves	Older caribou	Total	Calves	Older muskoxen	Total
Stratum 1							
1	14.4	0	0	0	0	0	0
2	33.6	0	0	0	0	0	0
3	44.8	0	0	0	0	0	0
4	84.8	0	0	0	0	0	0
5	121.6	0	0	0	0	0	0
6	124.8	0	0	0	2	9	11
7	126.4	4	11	18	0	0	0
8	121.6	0	0	0	0	0	0
9	105.6	0	0	0	0	1	1
10	86.4	0	0	0	0	0	0
11	75.2	0	0	0	0	0	0
12	54.4	0	0	0	0	0	0
13	44.8	0	0	0	0	0	0
Total	1038.4	4	11	18	2	10	12
Stratum 2							
1	11.2	0	0	0	0	0	0
2	35.2	0	0	0	0	0	0
3	56.0	0	0	0	0	0	0
4	72.0	0	0	0	0	0	0
5	136.0	0	0	0	0	0	0
6	161.6	1	7	8	0	0	0
7	153.6	0	0	0	0	0	0
8	131.2	5	8	13	0	0	0
9	153.6	0	0	0	0	0	0
10	160.0	0	0	0	0	0	0
11	166.4	2	6	8	0	0	0
12	145.6	0	5	5	0	0	0
13	136.0	0	7	7	0	7	7
14	126.4	0	0	0	0	1	1
15	24.0	0	0	0	0	0	0
Total	1668.8	8	33	41	0	8	8

Appendix B. (continued)

Stratum Transect number	Transect area (sq km)	Number of caribou			Number of muskoxen		
		Calves	Older caribou	Total	Calves	Older muskoxen	Total
Stratum 3							
1	9.6	0	0	0	0	0	0
2	67.2	0	0	0	0	0	0
3	83.2	0	0	0	0	0	0
4	89.6	0	0	0	0	0	0
5	108.8	0	0	0	2	4	6
6	105.6	0	0	0	0	0	0
7	113.6	0	0	0	0	0	0
8	115.2	0	0	0	0	0	0
9	116.8	2	13	15	0	0	0
10	116.8	0	0	0	0	0	0
11	116.8	0	0	0	0	0	0
12	100.8	0	0	0	0	0	0
13	73.6	0	0	0	3	8	11
14	40.0	0	0	0	0	0	0
15	40.0	0	0	0	0	0	0
Total	1297.6	2	13	15	5	12	17
Stratum 4							
1	57.2	0	0	0	0	0	0
2	48.8	0	0	0	0	0	0
3	60.8	0	0	0	3	11	14
4	69.0	0	0	0	1	6	7
5	64.4	0	0	0	6	20	26
Total	300.2	0	0	0	10	37	47